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THE SOLAR COMPASS.

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I have prepared the following communication in the belief that the common practice in the use of the Solar Compass can be improved.

One of the sources of error in the work done with this instrument is the effect of atmospheric refraction upon the apparent place of any celestial object. Atmospheric refraction causes an object to appear higher than it really is. The declination of the object is thereby apparently changed. This change should be allowed for upon the declination arc of the instrument. Heretofore there seems to have been no very good rule for finding the amount of this change. It may be found as follows:

CONDITIONS.—Let the latitude of the place of observation, and the apparent declination and hour angle of the object, as the sun, be given.

RULE.—From a table of natural sines and tangents, take the cosine of the hour angle and the cotangent of the latitude. Multiply one of these by the other. Call the product the tangent of an angle. Take out of the table the corresponding angle. If the declination is of the same name as the latitude add it to this angle, if of the opposite name, subtract it. Take out of the table the cotangent of the result. Multiply this cotangent by fifty-seven. The product will be the required correction in seconds of arc. Reduce it to minutes if necessary. If the declination be of the same name as the latitude add this correction to, and if of an opposite name subtract it from, the given declination. The result will be the quantity to be set off on the declination arc.

REMARKS.—If it happens that the given declination is greater than the given latitude, and of the same name, subtract the above correction from the declination. The quantities taken from the tables should be taken to two places of decimals, using the nearest figure for the last place; or to the nearest minute, as the case may be. The method of finding the declinations, hour angles, and corrections for a day's work is supposed to be familiar to surveyors who are capable of using the Solar Compass and but little time is necessary each evening to prepare a list of quantities for the succeding day's work. When the result found by applying the declination to the auxiliary angle is less than 10°, the altitude of the object will always be less than 10°, and it is not desirable to work by an object whose altitude is less than this.

With the quantities found by this rule set off on the declination arc, run the instrument with the centre of the sun's image at the dot of the silver plate. This will be found to relieve the operator from estimating the position of the sun's image as some persons direct him to do. Indeed, Mr. Burt himself does. The declination list prepared in this way is correct, for the purposes of this instrument, for a mean temperature of 50° Farenheit, and barometer at 30 inches. The range of the correction for the temperature will change the above corrections about half a minute of arc during a year, at the same place. The local atmospheric conditions, especially near the horizon will frequently make changes in the observed declination of an object amounting to many times this. Indeed, it is believed that the hygrometric and other conditions of the atmosphere under observations with this instrument are exceedingly liable to error. These errors may be regarded as small, but if they conspire at times to combine, as they seem to do, the result is far from satisfactory. The skill and judgment acquired by an intelligent practice in the use of the Solar Compass is the only means at hand for overcoming these and other difficulties. This is not an instrument to be run and used by every person who claims ordinary intelligence. If reliable results are desired careful preparations should certainly be required.

TORONTO CORRESPONDENCE.

The Commissioners appointed by the Dominion Government to investigate the nature and extent of the commercial advantages to be derived from the construction of the Baie Verte Canal—projected to connect the Bay of Fundy with the Gulf of St. Lawrence,—have presented their report accompanied by the evidence taken in connection with the investigation. The Commissioners have no hesitation in expressing their opinion that it is not in the interest of the Dominion that the proposed canal should be constructed.

The Waterous Machine Company of Brantford, who sent one of their portable saw mills to the International Exhibition in Chili, South America, have learned that it was awarded first prize and gold medal over five competitors—two from France, and three from England. This is true "Canada First."

The location survey of that part of the Pembina Branch of the Canadian Pacific Railway, between Winnipeg and the crossing of the Red River, some 18 miles north, was completed on 28th of February. The grading between Winnipeg and Pembina is well advanced.

The town of Sarnia is to have water works. Work on the engine house is already commenced.

Several towns in this Province are, within the current year, to be lighted with gas manufactured from Canadian petroleum.

The Credit Valley Railway Company petition the City Council of Toronto, for an additional bonus of $250,000—the bonus already given being $100,000.

Street Railways are now in operation in the following cities and towns in Ontario; and many others are chartered or under construction: Ottawa, Toronto, Hamilton, London, Windsor, and Sarnia.

In consequence of unexpected difficulties met with by the Government engineers, the contract for the Georgian Bay Branch of the C. P. R, from Lake Nipissing to the mouth of French River, has been cancelled by the Government. The contractor, Hon. A. B. Foster, declines to proceed unless he gets "better terms."

The Dominion Government has supplied the engineers of the Quebec and St. John railway Co. with meteorological instruments for the purpose of observing the temperature, rain and snowfall, etc., of the district to be traversed by the proposed railway. Were all railway and land-surveying parties in the United States and Canada to make such observations, a mass of valuable information could be obtained at a trifling additional expense.

Mr. Thos. Keefer, C. E., has just been elected President of the Ottawa, Vaudreuil and Montreal railway Company. Surveys have been made, and bonuses voted in certain localities, but work has not yet commenced.

It is expected that the Canada Central railway extension, from Renfrew to Pemroke, will be opened for traffic next month. And it is intended next year to change the guage of the Brockville and Ottawa, and the Canada Central railways, from 5 feet 6 inches to 4 feet 8½ inches.

Under a recent arrangement completed in Montreal, Mr. McDonald, the contractor for the Montreal and Ottawa section of the Q. M. O. and O. railway, will be able to carry out his contract. When work was suspended, over a year since, the grading had been nearly completed from the St. Lawrence to High Falls on the Nation river, and the fencing of that portion of the line was well advanced.

CANADENSIS.

Toronto, March 14, 1876.

The London Underground Railroad carried 26,500,000 passengers last year, and earned a dividend of 4 per cent.

Notes.

Fairbanks, Brown and Co., Scale makers, now make scales with two parallel arms, one weighing kilograms and the other weighing pounds.

The *Boston Herald* says that plans and surveys are nearly completed for a narrow guage railroad from Boston to Newton, a distance of eight miles.

Telford roads should be "kept up" constantly by applying small quantities of fresh material at frequent intervals as soon as depressions are perceived.

A petition has been presented to the City Council of Boston, signed by firms representing $100,000,000 of property, also by a large number of physicians, praying for immediate action to give the city a defined system of parks, sewers, and drainage, on the ground of its necessity and the cheapness of land and labor. The scheme which has been presented proposes an expenditure of something like six or eight millions for a complete sewerage and park system.

Capt. James B. Eads reports to the South Pass Jetty Company at St. Louis, that a remarkable deepening of the channel on the bar has occurred since the 4th inst. The old crest of the bar is entirely gone and the present crest is at station 93, or 9,300 feet from the shore end of the jetties. From station 93 to the sea ends of the jetties the depth of water varies from 17 to 20 feet. The outer slope of the bar deepened rapidly during the recent storm. The contractors are now pushing forward the work at the head of the pass and are preparing to close Grand Bayou. The Florida and Havana Steamship Company is preparing to send all their vessels through

The construction of the Water Works at Logansport is being pushed forward as rapidly as possible. The system adopted is that of direct pressure. The pumps are made by Cope and Maxwell, of Hamilton, Ohio, to be run by water power. There will be two 54" and one 42" turbine wheels under 12 feet head of water; also auxiliary engines in case of failure of water power. The capacity is to be 3,000,000 gallons daily; there will be 10¼ miles of pipe laid; these are made by H. R. Smith of Columbus, Ohio, who sub-lets the laying to T. B. Farington, of Chicago. The total cost of the water works will be $160,000, of which $40,000 has been paid for water power and real estate. The entire work is under the charge of W. A. Osmer, City Engineer, and J. A. Johnston, Asst. City Engineer, and is to be completed June 1, 1876.

A memoir of Mons. R. Pictet, submitted to the Academy of Sciences, at Paris, upon the application of the mechanical theory of heat to the study of volatile liquids, announces the following laws:

1st. For all liquids the cohesion is constant.

2d. The derivative of the Napierian logarithm of the quotient of the tensions divided by the temperatures is constant for all liquids, when they are compared at the same pressure and the same temperature.

3d. The latent heat of all liquids, with reference to one and the same pressure, multiplied by the atomic weight referred to the same temperature, gives a constant product.

4th. For all liquids, the difference between their latent heats at any two temperatures, multiplied by the atomic weight, is a constant number.

Finally, if we examine the results of the study of the laws of Dulong and Petit on specific heats, we can say that:

5th. The latent heats of all liquids are multiples of the specific heats.

HEAT AND COMBUSTION.

Third Paper read before the 'Railway Polytechnic Society,' Cleveland, Ohio, Jan. 17th, 1876.

BY P. H. DUDLEY, C. E.

[CONCLUDED]

FELLOW MEMBERS:—As intimated in the "Second Paper," I am able, from subsequent experiments, more fully to confirm some of the ideas advanced as to the loss which occurs from admitting an excess of air into the fire boxes of locomotives, steamers, and in fact, into any place where an intensity of combustion is desired.

As in this paper I wish to present for discussion some of the facts brought out by the many analyses now made, I will ask you

1st. To consider some of the conditions of combustion.

2d. The means used to induce combustion.

3d. To judge of the efficiency of those means by the chemical analyses of the products of combustion, and by the amount of work done.

At the very outset of our discussions we are confronted by the ambiguity of the term combustion, in that it has so many significations.

It is used to denote the combination of oxygen with carbon and hydrogen in the decay of wood, or when burnt in the fire, or the burning of coal in our stoves, under boilers, and in blast furnaces; and in these we have various degrees of intensity, all under the term combustion. Then we speak of complete and incomplete combustion. We will define complete combustion as a union of the oxygen of the air, and the carbon and hydrogen of our fuels in their proper proportions, producing a certain degree of intensity. In our "first paper" we pointed out that the calorific value of our fuels was not affected by the slowness of combustion, but that its intensity depended entirely upon the activity of the combination, the amount of the products, and the excess of air through which the generated heat must be distributed.

As we must have intensity to produce certain effects, it becomes important to know how to obtain it when desired. Although, as we have previously said, the principal elements which enter into combustion, in our fuels, are carbon and hydrogen with oxygen of the air, the two former enter into so many different combinations that in burning a piece of bituminous coal two distinct processes are called into action. 1st, Expelling and burning the volatile portions, the hydrocarbons of the coal; 2d, burning up the solid part or the fixed carbon.

In the first we have flame or smoke just as the necessary conditions are supplied.

In the second we have but little flame, merely a state of incandesence of the burning material.

Our first inquiry will be as to the structure of flame as one of the conditions of combustion. Take that of a candle, which Faraday made so instructive some years since. It has three distinct cones. The inner one consists of gas, formed by the destructive distillation of the materials of the candle; in fact it is a minature gas works. With dexterity and care the gas may be conveyed from the central portion by a glass tube and lighted. The next cone emits a white light, and the outer one a pale light, scarcely visible, except at the lower and upper portions of the flame.

In the second or luminous cone the liberation of carbon is due to the decomposition of the hydrocarbons by heat which separates the carbon from the hydrogen, and the latter by combination with the oxygen heats up the carbon so that it renders the flame luminous. The outer flame may be called the zone of perfect combustion. In the luminous cone the presence of the unconsumed carbon is shown by its deposition upon the introduction of any cold metalic substance which reduces the temperature below the point of ignition of the carbon and oxygen. If we put a wire gauze over the flame we can cool it so low that the carbon is deposited as soot. It will be well to keep in mind the necessity of an igniting temperature for carbon, as we shall again refer to it. In order to secure a flame suitable for the purposes of illumination, a sufficient supply, but not an excess, of oxygen must be given to it, which is well shown in gas burners of the fish-tail and bat-wing shapes, as also in the Argand burner. In the latter, without a chimney, the flame is red on the edges and smoky, because the gases are cooled down by the surrounding air; but when the chimney is put over it the excess of air is cut off, and a greater velocity given to that which comes in contact with the flame, increasing the temperature sufficiently to raise the carbon to the point of ignition with the oxygen, and thus preventing the flame from smoking. The luminosity of a flame is materially affected by the pressure of the medium in which it burns, the greater density giving the brighter flame,—although the quantity burned is said to be nearly the same,—and the heat given out is in nearly the same ratio.

Dr. Frankland, in 1859, ascended Mont Blanc and made some experiments upon the burning of candles; before making the ascent they weighed carefully and burned candles for one hour at the base of the mountain noting the size of flame and the loss in weight of the candles; ascending the mountain the candles were burned a certain length of time and the size of flame noted, also the loss of weight of the candle. The flames at the base of the mountain were large and luminous, but at the top of the mountain were mere specks almost without luminosity. The Dr. was much surprised at finding that the rate of consumption of the material of the candle had been the same at the top as at the bottom of the mountain. He explained this phenomenon by saying that the greater mobility of the air at the mountain top permitted the oxygen to penetrate the flame and intermingle with the gas, as in the Bunsen burner, not producing much light. The carbon is not raised to incandesence before being burned, but is consumed at the same time with the hydrogen without rendering the flame luminous; the oxygen penetrates every portion of the flame. We often see the light of our street lamps nearly destroyed by a gust of wind because the oxygen is blown into the second flame and mingles with the gas as in the Bunsen burner.

Our fires burn brighter in winter than in summer owing to the greater density of the air, there being more oxygen in a given space. When work is carried on under the caissons for bridges, much smaller wicked candles are used than in the open air, owing to the compression of the air to two or three atmospheres. The same thing is seen in the blast furnaces, also in the fire box for an instant when the blast draws in the air with great rapidity—compressing it to some extent.

Before the solid portions of the coal of the fixed carbon is burned, the gas has been dispelled; a process of destructive distillation has taken place, breaking up and liberating the volatile portions of the coal. Gas is formed not unlike that in the candle, and to burn it without forming black smoke the proper conditions must be supplied. Air in the right place and proper quantities, heated to an igniting temperature, must be furnished. If we wish to light a fire we first take a match on which there is some phosphorus, which ignites at a very low temperature, simply that induced by slight friction; then some sulphur is ignited and finally a small piece of wood. Next we can light some shavings, they in turn some small sticks, and their heat, some small pieces of coal. We do not attempt to light the coal by friction, but we prepare for the work we wish to do.

Our smoke or black carbonaceous matter comes from the hydrocarbons, from the reasons previously stated, viz.: that the hydrogen unites with the oxygen at a lower temperature than carbon and oxygen; and the carbon, unless the heat is sufficient for it to unite, passes off as soot or black smoke.

It is said by those who have experimented upon combustion that oxygen and hydrogen combine at 315.5° Cent. or 600° Fahr., and that oxygen and carbon do not combine below a red heat, 538° Cent. or 1000° Fahr.

Authorities differ, however, as to the heat of flames, and the various degrees of color seen in fires.

I have prepared a table of high temperatures based on the researches of Pouillet.

	Cent.	Fahr.
Incipient red heat	525°	977°
Dull red	700	1292
Incipient cherry red	800	1472
Cherry red	900	1652
Bright cherry red	1000	1832
Deep orange	1100	2012
Bright orange	1200	2192
White heat	1300	2372
Bright white heat	1400	2552
Dazzling white heat	1500	2732
Full white heat	1600	2912

HEAT OF FLAMES.

	Cent.	Fahr.
Coal gas flame	1288°	2350°
Carbonic oxide	1671	3042
Hydrogen flames (in air)	1793	3259
Oxyhydrogen flame	4460	8061

These temperatures occur under the best conditions, and would only be realized under similar circumstances. It will not be possible to attain such temperatures under boilers, where the water takes away the heat so rapidly. I am well aware that it is quite easy to state the conditions of perfect combustion but much more difficult to secure them. As an example, observe a cubical piece of coal as it burns in a fire-box. The under side, almost as soon as it reaches the incandescent fuel upon the grates, undergoes destructive distillation, and the gas, if hot enough, bursts into flame, enveloping the sides and upper portion of the piece of coal, *excluding air from its upper surface and a large portion of the flame.* Although the air may be drawn into the fire-box in excessive quantities through the grates, as it rushes by the sides of the coal, it cannot reach its upper or top surface. Consequently enough oxygen is not presented to combine with the carbon, as it is liberated by the burning of the hydrogen. Other portions of the flame, by contact with the boiler, or by the great excess of air coming through the grates and passing up the sides of the pieces of coal, are cooled down so much that the volatile carbon passes off as so much soot or black smoke, *taking away* instead of making heat.

These are the reasons why it appears in the analyses of the products of combustion, especially on the C. and P. R. R., that a much smaller percentage of carbonic acid is formed, and the greatest percentage of oxygen is found in the fire-box just after firing, when the smoke is the blackest. *It needs air over and in contact with the surface of the burning coal to most effectually consume the black smoke or volatile carbons; this air should be injected down on to the surface of the coal, and not simply into the fire-box at the door, some two feet above the burning mass, as the igniting temperature at or above the door is seldom obtained.*

The value of steam jets playing over the surface of the burning coal arises from the fact that they help to supply the top surface of the coal with air, *e. g.* they break up the cones of flame, permitting the oxygen to have free access to all parts, and as this occurs so near the incandescent fuel, where the heat is much more intense than at two feet above it, the carbon as well as the hydrogen is more likely to have an igniting temperature. In buying or burning little distinction is made between dry steam coals and those containing more bituminous matter, which runs together when fired, preventing free access of air. There is no change made in the plan of construction of the fire-box or grates, for the various kinds of coal; yet people expect to get just as good results from one coal as another, whose chemical composition requires different conditions for perfect combustion. No one would expect that iron would do as well for a cutting instrument as steel, yet it is about as incongruous to expect that all the various coals will do as well in the same style of fire-box and grate.

In taking up our second question,—the means to induce combustion—the first important consideration is how much air must we admit, besides that required for combustion, to dilute the products. For slow draught produced by chimneys, the general impression seems to be that as much air is required for dilution as for combustion. I will give some of the results of my investigations upon that point. I had a good fire built in a Clipper stove which has a large grate area. In the pipe, about six feet above the fire, there is a small hole covered by a cap, which we could remove, and we could then insert the pipe of our gas pump. 100 volumes of the gas analyzed, gave the following results:

	Volume of gas.	Carbonic acid.	Oxygen.	Nitrogen.
1.	100	1.7	18.8	79.5
2.	100	1.7	19.1	79.2

The small percentage of carbonic acid and the large percentage of oxygen shows the great excess of the latter drawn in by the draught and unconsumed. The most of the heat of the coal was conducted away, by this excess of air, through the pipe to the chimney. We now opened the stove door and collected the gas from the flame just above the burning coal, with the following results:

	Volume of gas.	Carbonic acid.	Oxygen.	Nitrogen.
3.	100	11.1	5.8	83.1
4.	100	10	9.4	80.6

One object we had in making these experiments in the stove, was to see just the place in the flame or on the coals where we collected the gas, so as better to enable us to interpret the results of the analyses from the gas taken from locomotives, where we can seldom see the character of the flame. The gas was analyzed by Mr. Kinsman as soon as taken. By observing the place whence we were taking the gas we could see whether the hydrocarbons were escaping or not, and in specimen 3 the reading above 79 for the nitrogen is due to the hy-

drocarbons, and, in fact, we might say this of all of them.

We collected and analyzed many specimens but I only give a few of them as they were so similar.

	Volume of gas.	Carbonic acid.	Oxygen.	Nitrogen.
9.	100	16.1	3.7	80.2
10.	100	16.5	2.7	80.8

In these last mentioned specimens the pipe of the gas-pump was so surrounded by the incandescent fuel, that no air could get to it which did not pass by the hot pieces of coals. No one will fail to notice the large increase in carbonic acid and decrease of oxygen. Even when the gas was taken from the flame the percentage of the carbonic acid was largely increased over that in the specimen taken from the stove pipe, in one case 6.5 times, and in the other 5.9 times. It might be objected to my withdrawing the products of combustion from the burning coals, that it would have the same effect as forcing in air at a more rapid rate. We could not detect any difference in the results, whether we collected the gas slowly or fast. We tried many specimens from the stove with results as given in the last analyses. The pipe was surrounded by about 3 inches of the hot coals, and of course in some of the crevices the column of air was so large it did not all come in contact with the coal. To see what the effect would be in a parlor grate, we allowed all of the volatile matter to pass off, and then covered the pipe on all sides with 4 inches as nearly as practicable of the incandescent fuel.

The following four analyses will show the average results of the gas collected.

Volume of gas.	Carbonic acid.	Oxygen.	Nitrogen
100	17.5	3.1	79.4
100	17.5	3.1	79.4
100	16.2	4.5	79.4
100	16.1	4.4	79.5

The last two specimens were taken from coals as they were burning so that the air spaces had increased in size. Some time is required to analyze the gas and as we did not wish to take it until a moment before it was wanted, it was quite difficult to get more than two specimens under nearly the same circumstances. We also took some specimens from Anthracite coal in a base burner, the pipe of the gas burner being covered only about two inches deep by the incandescent fuel, and more or less air had access to the end of the pipe.

Volume of gas.	Carbonic acid.	Oxygen.	Nitrogen.
100	14.4	5.5	80.1
100	16.5	3.7	79.8
100	15.3	5.6	79.1
100	14.7	5.7	79.6

The coal was not first quality of anthracite having some bituminous matter in it. In a larger fire much better results, *i. e.* more carbonic acid would be obtained.

Now, when we examine these imperfect results, and we call them imperfect because the gas was not obtained under the most favorable conditions, the draught was very moderate, and because perfect combustion would give from 20 to 21 per cent. of carbonic acid, according to the impurities in the fuels,—are we to conclude that we must have double the quantity of air admitted into fires to dilute the products of combustion? I am far from being convinced that a large excess of air is required for this purpose. Because we find a portion among the products it does not imply its necessity.

Take the analyses from the parlor grate, with the mouth of the chimney nearly 1 foot above the mass of incandescent fuel: the draft is but slight, and, as the air passes up through the coals, *its course is interrupted and by the eddies formed in its passage nearly all the oxygen is taken up by the carbon.* Consequently we have more complete combustion in the fuel than we do when the air spaces are greater, showing that the currents of air must be deflected and broken up so that all of the oxygen can have access to the burning fuel. In our land boilers the chimney is the usual means of inducing the necessary draught for combustion. In locomotive boilers the exhaust steam. In marine boilers both are used, either separately or combined. In the first case the draught is quite moderate through the grates, and in the second case there is more or less action according to the degree of pressure produced. It will not be necessary for me to speak in this place, in detail, of the various kinds of grates in use, or the methods of admitting air over the fuel, as it will be quite sufficient to speak of these more fully when we take up our third question, to judge of the efficiency of these means by our analyses, and the amount of the work done.

I sometimes think we lose sight of the important fact that the boiler, water and engines are but the means to gather up the force in our fuels, to catch the motion as it is liberated by combustion. Heat is no longer considered as a substance but as a mode of motion, a force set free by chemical combination, the result of clashing atoms, and as capable of conversion into work. It is not the boiler, it is not the water, it is not the engine which does the work,—it is the force generated by the combustion of the fuel, the heat developed which does the work, and we should save it, make it pass through the motor, and not allow it to escape from the fire-box, boiler, engine, and by the great excess of air drawn into the fire-box. The locomotive is a peculiar motor, its condition of working constantly changing, sometimes working at its full capacity and at the next moment being reversed by the previously acquired momentum of the train. Consequently the combustion must be rapid at times and slow at others, and it cannot be expected that the same arrangements will be most suitable for the different circumstances.

When making experiments upon the C. and P. railroad, we found the maximum rate of combustion to be per square foot of grate surface 1.082 lbs. per minute or 65.9 lbs. per hour. The area of the grate is 14.79 square ft. in their standard freight engines.

On the L. S. and M. S. railroad, with a grate of the same area, the maximum rate of combustion is much higher. On this road we did not time the firing per minute, yet, from the total amount of coal used in our trips, the maximum must reach 110 lbs. per square ft. per hour. On this road they use two 3-inch exhaust nozzles. On the C. and P. railroad they use a single nozzle, 4½ inches in diameter, formed by the union of two nozzles, each equal to one half the area of a 5-inch circle or each equal to 9.83 square inches. Those upon the L. S. and M. S. railroad are each equal to 7.07 square inches. The greatest percentage of carbonic acid we would get in case of perfect combustion is 21 per cent. If our analyses show less, then we know at once that complete combustion has not taken place and we must look for the cause. If we find a large percentage of hydrocarbons we see at once that they pass away unconsumed because the temperature is so low they cannot combine with the oxygen: air in the right place is not furnished to them. The sides of the boiler and the crown sheet are so close to the coal that the flame is cooled or the many small flues extinguish the flame before combustion has taken place. The escaping hydrocarbons are easily detected by the dark color of the smoke. If there is not sufficient air, carbonic oxide is found which can only be detected by analysis, as it is invisible, and passes off unheated.

Before making these analyses I was of the opinion, from reading upon the subject, that this was the great source of loss. It is very seldom that we find even a trace of this gas, the great loss occurring from the excess of air.

It is clearly shown, by studying the results of the analyses of gas taken from stoves and the house grate, that to burn the coal with the least amount of air the grates should be fine, separating the air into minute streams, causing it to come in contact with the incandescent fuel, and causing the carbon to absorb all of the oxygen. Examine the construction of the grate used upon the C. and P. railroad which was fully described in the "second paper;" also the one used by the L. S. and M. S. railroad which is essentially of the same area, but in each rocking box the air enters through 46 1¼ inch round holes. A glance at the analyses of the two railroads shows at once the great difference in the amount of carbonic acid obtained.

It is plainly evident that for grates constructed with large air spaces, separated by wide portions of metal, the proper conditions will not be fulfilled so perfectly as with small and more frequent air spaces. The usual practice of carrying a light fire with such short blasts as are in general use is not conducive to an intense combustion. No matter how skillful the fireman, it is impossible for him to keep just sufficient coal on the grates to prevent the air from rushing through them in great volumes which cannot come in contact with the burning fuel. This air, therefore, takes away instead of adding any heat to the fire. As soon as a stream of air, no matter how small or large, enters the hot fire-box, it exhausts and enlarges its size. Consequently the atoms of oxygen are more diffused, and, unless the currents are violently and rapidly deflected, so as to break up the stream of air and bring all parts of it in contact with the coal and gas, a large portion of the latter passes away to the chimney unconsumed, either because it was so hurried, surrounded by such quantity, or the carbon cooled so low that it would not unite with the air, or we find more oxygen than can possibly unite with the fuel. To mix quickly two fluids, we would not turn the one into the other in a great stream without agitation, but in small streams with rapid, violent motion. In the fire-box it is much more difficult to make the necessary agitations except by the very currents of air we are introducing. They should, therefore, be small, and the overlying pieces of incandescent fuel will aid very much in breaking up the currents, making eddies in the air, turning the inside of the streams outwards, so that all of the oxygen can take up its carbon, giving heat in return.

The elements combine according to fixed laws and are not in the slightest sense accommodating. If we want carbonic acid made we must supply the necessary conditions. The atoms will not make up for us what we fail to give them, or use up the excess of air. Two atoms of oxygen, no more or less, unite with one of carbon to make carbonic acid. It has no theoretical line of action; no compromise line of action; it has but one practical line of action—making carbonic acid when the necessary conditions are supplied; and it is of no use for us to expect that with some fancied project, some fancied invention, not based upon principle, we have but to give the command and the elements will combine as we bid them. If we present but one atom of oxygen to each one of carbon, we have carbonic oxide, with a loss of nearly two thirds of the heat produced when carbonic acid is made. If we present three atoms of oxygen to one of carbon, but two are taken, and the heat is reduced to warm up all to the same temperature. If we admit double the quantity of air into our fire boxes—I should say force it in—we must not expect it will be used, that is, converted into carbonic acid, It is contrary to the very laws which preserve the stability of the Universe. In all of our experiments upon locomotives we have found the most complete combustion where a moderate blast was used in connection with the fine air spaces. We have not had any opportunity to make any analyses of gas when a proper amount of air was admitted over the door to burn the hydrocarbons upon locomotives. Take the maximum rate of combustion of the C. and P. railroad per square foot of grate surface per minute at 1.082 lbs., and for the entire grate of 14.79 square feet, it would equal 16 lbs of coal per minute. To just furnish the necessary oxygen for this amount of coal required (at the temperature of the air when the experiments were made) 12576 cubic feet of air, one fourth of which, or 644 cubic feet, would be required to burn the hydrocarbons, and this quantity to produce the best effect, should come in contact with the coal from above the grates and not through them. If the oxygen is promptly supplied the flame does not stream out so long, which makes it quite important in the fire-boxes of locomotives,—where there is only from 50 to 70 cubic feet in which combustion can take place,—that the combinations be made as rapidly as possible, as the small flues extinguish flame as soon as it enters them, preventing any further combinations.

An igniting temperature for the combustion of gases is almost ignored; and yet one would think it would be the first point to receive attention. We open a gas jet to the air, but it does not ignite, and we are obliged to light it with a match before any combustion takes place. Heat increases chemical activity, as fully exemplified in the blast furnace, and regenerative furnaces, where the air is heated up before it enters into combination with the elements of our fuels. It was a grand step in metallurgy when the hot blast was fairly introduced; the increase of iron doubled. It will be a grand step for steam users when they utilize much of the waste heat by returning it to the air raising its temperature, similarly to the hot blast, before it comes in contact with burning fuels. In every pound of exhaust steam there are 637 unexpanded units of heat, a portion of which can be returned to the fire and boiler. This would not be perpetual motion, but simply a transformation of fire so that it could be again hastily used.

Gases form by such fixed laws, and in such relative proportions, that from an analysis, together with the amount of fuel consumed per minute, the loss in heat units can be calculated with tolerable accuracy, as far as combustion is concerned. Take any of the analyses treated in the several papers, or those in this, and with the amount of coal used in a given time, the loss due to an excess of air can be shown. In the blast furnace, where the matter has been quite closely studied, great economy has been produced by following the changes suggested, from a study of results; and as much improvement can be made in locomotives, steamers, housegrates, and places where heat is obtained from burning coal. We recently measured the force required to move a freight train from Cleveland to Erie, and the number of pounds of coal to do it; *less than six per cent of the theoretical value of the fuel was required.* I am quite safe in saying that, upon railways, this will be found nearly a maximum percentage. This occurs too in a country of boasted institutions, knowledge, wisdom, ease, and comparative wealth.

All of this loss of power is not due to imperfect combustion, yet the latter forms a very large part of the former. You are already familiar with the products of combustion, and can see the importance of being able to judge with certainty of the chemical reactions which are constantly going on in our burning fuels. As we have seen, a slight change in their conditions is either failure or success, more especially is this remark true when applied to metallurgical operations, which are largely dependent upon chemical reactions. The great industrial question of the time and one which has much to do with the activity and prosperity of a country is, how can we obtain more nearly the theoretical value of our fuels, or, in other words, how shall we make our heat generators? Shall it be by disregarding or following sound principles?

We have not been able to test practically, in all of their bearings, the ideas herein advanced, but the study of the results obtained upon the two different railways, induced us to ask Mr. Chapman, Master Mechanic of the C. & P. R. R., to decrease the air space in his rocking bars from ½x6 inches to ⅜x6 inches. The grate was put into engine number 84, of his construction, Dec. 9. 1875, which has been in constant service without repairs since Dec. 1872; consequently her flues are somewhat incrusted with mud and lime. During the part of the month of December, in which she had the changed grate she used less coal, with one exception, than any of the eighty engines in service, many of which were just out of the shop. The subsequent months of January and February, 1876, show that her car mileage per ton of coal has been increased with the changed grate 90 to 95 miles with same weight of train, a saving of from 15 to 16 per cent of fuel. These may be more than average results, yet they show the gain from following out principles. When we shall be permitted to alter the fire door and to arrange the grate fully in accordance with the facts already discovered, we expect, without any complication of furnaces, to save from 25 to 40 per cent of the fuel, or, in other words, to increase the efficiency of furnaces to that extent; the saving in heat and its application after it is generated, is another matter, and one for further investigation. The total useful effect, or the actual value, of the fuel consumed in running a train from Cleveland to Erie, on the L, S. & M. S. R. R., as measured by the dynagraph, was only 4 per ct.; some of the engines they have in use may increase it to 4½ or 5 per cent. When we consider that our best steam engines do not give us over 10 per cent of fuel it is apparent that there is much room for study and investigation.

ENGINEERING NEWS.

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DESCRIPTION OF ENGINEERING WORKS.

The most instructive reading, probably, to an engineer engaged in the practice of his profession is of that class which embraces detailed accounts of the construction of permanent works. An engineer becomes valuable to a community in just that degree in which he has had experience, or has been able to profit by the experience of others. Most calculations founded on the formulae derived from books and tables, involve the use of data which have been obtained from experiments; but these experiments have often been made on a small scale, on materials carefully selected, and under circumstances which may not always be reproduced in a larger structure to which the derived formulae are applied. A sensible man will of course profit by the results of his own work learning from his success, from the endurance of his constructions under the stress of time and climate, what means may again employed, and, from his failures, what should be avoided.

A careful perusal of the expedients which others have employed, with success or otherwise, to overcome obstacles and difficulties, will also guide him in the right course to be pursued in some new work which he may undertake. As well known examples of the class of books to which we refer may be taken Clark's "Quincy Railroad Bridge," and Chanute and Morison's "Kansas City Bridge." Here we find carefully set forth the way in which the swift current, the shifting sands, and the ice were successfully combated, the construction of false works, the excavating with dredges, sand pipes, etc., the behavior of the cassions, the type of superstructure, the tests of the parts and of the completed whole. The authors do not confine themselves to recounting their good fortune, but they, in giving account of the expedients which failed, also teach us, if we are wise, what to avoid.

Complete descriptive works of this nature are comparatively rare in this country although constructions in foreign contries have been more often described in detail by the engineers in charge. We do not however build much after European models and think that our constructions are generally better fitted to their places and to the conditions, pecuniary and otherwise, under which they are built, than a transplanted design would be. Engineers can however find, in a more or less permanent form, in the papers read before societies and published in their transactions, or in the pages of technical periodicals, accounts of the progress of works of various kinds, but generally giving a description of only a portion of the undertaking. In some cases the papers published in society transactions are limited in circulation to the members themselves, as in the case of our American Society.

Some notable and most instructive papers more recently published are those of Collingwood, descriptive of the sinking of the caissons of the East River Bridge, and of Capt. Eads, detailing the course of construction of the St. Louis bridge. For these, most engineers have to turn to the files of the well-known English paper *Engineering*. And, speaking of the St. Louis bridge, reminds us of the admirable paper submitted by Theodore Cooper to the American Society of Civil Engineers, on the method employed in erecting the great steel arches, and the way in which difficulties were surmounted. It is hoped that before long the NEWS may offer a vehicle to engineers for the presentation to the public of such articles, and that American engineers will not be obliged to search the files of ann Eglish paper for descriptions of works in their own country.

But can we not hope that we may see more of such monographs as those of which we first spoke? The desire to benefit the profession must be the ruling impulse with the author. The cost of illustration, without which the text is not nearly so satisfactory, will greatly increase the expense of production and the limited sale of technical works will prevent him from reaping any pecuniary profits. The introduction of lithographs, photo-lithographs, or heliotypes ought to help towards cheap production. There is however another reason why such books are scarce:—the time of an active engineer is so much taken up with the cares of business that he has little or no leisure to devote to book-making, while it is the experience of just such men which is most valuable and by which we most desire to profit.

SURVEYORS' NOTE BOOKS.

We have received several communications on the above subject, but their voluminousness precludes their being published. We do not see that they differ essentially from the examples given in No. 6, ENGINEERING NEWS, which we have no doubt will combine all the requirements that are necessary for such a publication.

We have so little respect for the office of County Surveyor (considered merely as regards the office itselt) and its utter irresponsibility as regards official decisions, that we cannot conceive of any need for these expensive and unwieldy books that seem to be its necessary adjuncts.

Why a County Surveyor's book of record, into which nobody but the incumbent of the office for the time being, ever looks, and the contents of which are valueless exbept as a matter of convenience to an occasional farmer, who does not comprehend it when he does look—should be of so much more importance than the note book of a Civil Engineer, or even of a City Surveyor, as to reduire an elaborately constructed book, printed in two or three colors, and with an acre or two of cover, is past our comprehension, except it be to give some stationers an opportunity to make some money. What more is necessary in a note book than some blank leaves, cross-sectioned on one page, if preferable, and bound in good stout covers so as to fit the pocket, in which the average surveyor can note his chaining and record his witness trees and monument?

A very few years in any region in America, and in the West especially, and the witness trees are cut down and grubbed out, and if adjoining farmers are not interested in preserving the monuments which define their boundaries, let them suffer the consequences. But because certain posts or other monuments *are* set, and duly recorded by a County Surveyor in an official note book, it is not a sufficient reason why a succeeding surveyor should accept this survey without a question, a fact which in our opinion detracts from the value of the record. A surveyor's records are not of much value in a court of law, but after they have been transcribed from the original book to another, they become less so.

There is more land surveying done in Cook County, Illinois, than in any three other counties west of the Ohio river, and yet there is no official record book kept by our friend Wolcott, who has filled the office from time immemorial, (and previous for aught we remember) and we think he ought to know whether there is need for one or not. He has sounded the depths of most of the outlying swamps of this county and staked out large portions thereof, but other surveyors have defined the limits of many a section and its fractional parts in Cook Co. who knew how to do it as well as our official friend does, and whose surveys are quite as much respected as are his. Now who imagines that the official record of his surveys confer on them more value than obtains for the unofficial ones?

We fail to see any more use for an official note book than we do for an official surveyor, and the sooner both are abolished the sooner will western land surveyors be freed from the trammels of ignorant legislation, the competition of official ignorance and incompetency, and the demoralizing influences of low professional status and grossly inadequate compensation for services performed.

We want several copies of No. 2 and No. 7 of Vol. 3 ENGINERING NEWS to complete sets, and will give *one month's subscription* for each copy of either of these Nos. sent us this month.

We have seen recently some handy little clips, designed to be attached to a triangular scale, to serve as a handle, but more particularly to enable a draughtsman to use the right edge, without looking each time to see whether he has the proper scale. They are made by the well-known mathematical instrument maker, J. W. Queen of Philadelphia and New York.

CORRESPONDENCE.

EDITOR ENGINEERING NEWS.—I have just read the Report of the Boston Drainage Commissioners published in ENGINEERING NEWS, with very great pleasure. It is an able report, and the names attached to it will no doubt have sufficient weight with the Bostonians for them to give effect to the suggestion contained in it.

There is only one point upon which I think there can be two opinions viz.: the crossing of the Neponset river by a syphon. My experience of syphons has been very unfavorable; in the event of anything going wrong they are awkward to get at, and the first cost is always very great.

I would advise that the grade of the Main Sewer from College Farm be brought down sufficiently at the lower end to pass under the river and then the Pumping Engines could be placed upon the other side.

This would increase the height to which the water would have to be pumped but this might be reduced again by lowering the outfall sewer a little. As arranged at present the mean high water just touches the invert at the outlet. As no sewage would be discharged for two or three hours after high tide the invert might be brought down to the mean level of water at halt tide, the time desired for discharge. A penstock would of course prevent the water from backing up into the storage reservoir.

I think your correspondents W. Y. and C. T. Jr, would find it more convenient to find the variation of the needle by taking any circumpolar star at equal altitudes—any of those in *Ursa Major* answer well,—and bisect the azimuth angle. The difference between the true north thus found and the reading of the needle will give the variation.

This method has the advantage of requiring neither calculations nor reference to a nautical almanac for time or change of declination.

JOSEPH SMITH, C. E.

Montreal, March 15th. 1876.

Temporary Trestling, and its Economy as Compared with Earthwork.

Abstract prepared for "Engineering News" from a Paper by J. W. Hoover, C. E.

Temporary Trestling is built of wood, and the design should be so arranged that any one of the pieces can be replaced at pleasure, since the renewal of a few parts may obviate the necessity for a new structure.

The economy of temporary over permanent constructions depends on many different things and must be determined for each case. The position and size of the depression to be crossed, the presence of flowing water, the nature of the bottom, all modify the kind of permanent works and make their cost vary greatly.

Gillespie states that "trestle work five feet high costs four times as much as earthwork;" and, in speaking of the Portage Bridge over the Genesee River, 800 ft. long, 190 ft. high and containg 1,500 m. ft. of lumber; he estimates that the cost, $140,000, was "one-fourth that of earthwork to have taken its place." Gillespie also states

that the cost of earthwork increases nearly as the square of the heights, that is as

$$a(x_2^2 - x_1^2,)$$

where a—tangent of angle of slope with the vertical; x_1—distance from intersection of slopes to road bed; and x_2—distance from intersections of slopes to the bottom of embankment. In very deep fills x_1 is quite small compared with x_2. The cost of trestle-work he thinks increases about as

$$(x_2 - x_1)^{\frac{3}{2}}$$

or as the height with an exponent $\frac{3}{2}$.

While the former value is true, the latter we think is too great. The parts of a trestle which increase with an exponent greater than unity are very few. As in most temporary trestles the bents are braced longitudinally, and the posts stayed laterally at equal intervals of height the posts may be considered as made up of pieces of length equal to the distance between the sets of cross-beams. By adapting these lengths to suit the timber used, the only element tending to increase the stress is that due to the weight of the timber and iron used in the bents and bracing. Since the stress at any section is equal to the stress at a higher section, plus the weight of the timber and iron intervening, that portion of the stress arising from the weight of the trestle varies nearly as the depth. In cases where this structure is practicable, the weight of the trestle bent is small compared with that of the engine and of the constant part of the frame. By reference to any example it will be seen that the cross-beams and sway-braces will increase very slowly in length with the depth. The girts or longitudinal braces will vary in amount as the depth. The cross-ties, stringers, rails, braces, and lower chords, or all the top work, as well as the moving loads, are constant.

The comparative prices of different structures, and whether the capital of the company will admit of the present outlay are also questions of moment. The time allowed for the completion of the line may not permit the erection of permanent works. But want of time and money do not concern the economy of *construction*. Loss in this way must be balanced against profits on transportation during time saved, and by interest on capital economized. If the trestle is designed to be quite temporary the foundations may be of a much cheaper character, than where it is proposed by replacement of defective timbers, to lengthen the life of the structure.

For the purpose of making some calculations as to the economy of trestling, we have taken the Old Forge Trestle, on the Valley Railway, near Akron, Ohio, designed by P. H. Dudley, C. E., of Cleveland. The design is excellent, sufficiently strong, and well adapted to permit of renewals. The sizes of timber are 3″x6″, 3″x8″, 6″x8″, and 8″x16″, and no piece is longer than 32 feet. Larger pieces may be converted into smaller for repairs, and a small supply will replace quite a variety of parts. The bents are 65 in number, 16 feet from centre to centre, and varying in height from 17 to 48 feet, They were designed to carry a load of 40 tons although probably never loaded heavier than 30 tons, on 16 feet. The posts are only 10 or 10½ feet between cross-beams and braces. The factor of safety is not less than eight with the above load, and in the important pieces is much greater.

The complete bills of materials have been made out, but we have room for the bill of timber only, for four bents 48 feet high, which will give an idea of the sizes and arrangement of pieces.

Batter posts:—8 pieces, 6″x8″, of each of the following lengths, 17′3″, 20′9″, 10′9″, 27′3″, 21′,

Posts:—8 pieces, 6″x8″, of each of the following lengths 17′, 20′2″, 10′6″, 26′8″, 20′3″,

Braces:—16 pieces, 6″x8″x12′.

Girts:—56 pieces, 3″x8″x18′.

Lower Chords:—4 pieces, 6″x8″x32′.

Stringers:—8 pieces, 8″x16″x32′.

Cross beams:—8 pieces, 3″x8″ of each of the following lengths, 12′, 13′, 18′, 23′, 28′, 31′.

Cross beams:—4 pieces, 6″x8″ same lengths.

Sway braces:—8 pieces, 3″x8″ of each of the following lengths, 14′6″, 17′2″, 21′6″, 18′6″, 16′6″.

Total timber in 4 bents 48 feet high, 17,568 ft. B. M.

Also required 312, ¾″ bolts, from 1′3″ to 2′¼″ long, and a few castings.

The amount of timber in the 65 bents is 217,234 feet, B. M., costing, including framing and erection $40 per M.—$8,689.36.

The bolts, 11,981 lbs.@6 cts.	$718.86,	
Washers, 3,400lbs. @ 6½cts.	221.00.	
Castings, 5,451 lbs. @6 and 5c	316.75.	
Patterns and trucking,	12.34.	
		$1,268.95.
Foundation, excavation, material left, engineering, and miscellaneous expenses,	$1,749.71.	
Total cost of trestle,		$11,708.00.
Earthwork for the same place, by computation, cubic yards,	87,779.2.	
Ten per cent for shrinkage,	8,779.9.	
Total cubic yards.	96,579.1.	
Cost at 28 cents per cubic yard,		$27,042,12.

There would also be required for openings, two stone arches, 30 feet span, estimated to cost $28,000.

As a portion of the road within a distance of two miles was excavated with a steep slope, the material which will gradually fall and wash down must be removed and can be deposited at this trestle for, at most 10 cents per yard over the expense of wasting it. But if the fill had been made at the time of erection of trestle, before the track was laid, the material would have been borrowed. It is estimated that this earth will not be moved till an average time of four years, and that the arches will be put in at the expiration of six years. We can make the following comparative estimate :

Cost of immediate permanent construction,		$55,042.
Cost of postponed permanent construction,	$28,000.	
	11,708.	
	9,658.	
		$49,366.
Saving of capital,		$ 5,676.
Comp. interest on $28,000 for 6 years @ 8 per cent.	$16.432.	
Comp. interest on $9,658 for 4 years @ 8 per cent.	3,481.	
Comp. interest on $5,676 for 6 years @ 8 per cent.	3,331	
Amt. saved by postponed permanent con.		$28,920.

The saving will be increased by allowing a greater durability for the timber.

From a careful calculation of the amount and cost of materials in each set of trestle bents of different heights, the following table is drawn out, showing the present comparative costs of trestle and earthwork, for a length of 16 feet along the line, for the heights specified and the prices per thousand and per cubic yard annexed.

As the girts, etc., are ten feet apart, while the tabulated heights vary by five feet increments, there is not a regular progression in the ratio of cost.

[We hope to publish detailed drawings of this design for a trestle before long.—ED.]

Table showing comparative cost of trestle and earthwork for various heights.

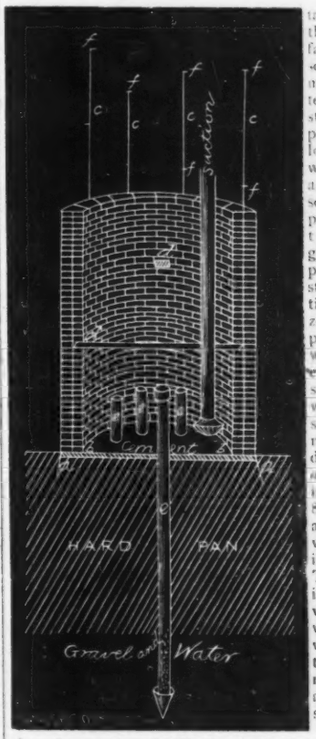
Total amount of timber in bents, Old Forge Trestle, 217,234 b. m. Total cost, $11,708. Cost per 1,000 feet b. m. including iron, foundation, engineering, etc. $53.90.

Height of trestle or embankment.	Amount of lumber, B. M. in length of 16 feet.	Cost of trestle at $53.90 per thousand.	Cubic yards embankment 16 feet long, 10 per ct. shrinkage.	Cost of embankment at 28 cents per cubic yard.	Ratio of cost earth to trestle.
17 ft	1,941	$104.60	415.6	$116.36	1.11
22 ft	2,201	118.62	645.3	180.69	1.51
27 ft	2,665	143.65	924.0	258.72	1.80
32 ft	2,964	159.76	1,251.6	350.04	2.20
37 ft	3,478	187.46	1,628.0	455.84	2.43
42 ft	3,808	205.25	2,053.3	574.53	2.80
45 ft	4,392	236.73	2,628.3	735.50	3.11

Sycamore, Illinois, Water Supply.

We illustrate below a simple, and, in some respects novel mode of construction for a water well, which, with some modifications, should be of value to numbers of our western cities and corporations contemplating water works or requiring such wells for other purposes. The dimensions given are essentially those being adopted by the city of Sycamore, in this state, in connection with their admirable water works otherwise just completed.

Wells previously sunk at this point had demonstrated the absence of rock and the presence of water at the depth of 70 feet. In locating this well a preliminary boring of 3 inches diameter was made at slight expense till water was reached, and the various quantities of earth withdrawn were carefully noted. This boring being satisfactory was made the center of the proposed well, which is 8 feet in diameter between walls, the walls being 8″ thick, of brick laid in cement. In this instance the nature of the soil permitting, an excavation was made to the depth of 20 feet before commencing the wall, when digging was suspended and the masonry laid to the surface of the ground. For the further depth contemplated the wall will be settled as fast as laid and simultaneously with the laying. To facilitate the settling and to maintain the integrity of the structure in the process the following devices were adopted, as shown in the sectional and partial illustration herewith given. A base piece was constructed consisting of a horizontal annular plate, *b b*, upon which the lower course of masonry is laid, to which plate was secured the nearly perpendicular flange, *a a*. This flange is of 3-16 iron, 8 inches deep, and flares outward about ¾ inch on all sides This flange cuts its way downward under the weight of the wall as fast as the earth is removed, making a passage slightly larger than the structure itself. In the horizontal base are secured six ⅞ upright bolts, *c c*, each 20 feet long and provided with several shoulders as shown at *f f*. These bolts are imbedded in the wall as it rises.



For the purpose of further strengthening the wall horizontal wooden braces, *d d*, extending from one side of the wall to the other, are inserted at intervals, their ends being embedded in the masonry.

At Sycamore, several feet of hardpan are encountered at a depth of 55 feet, and upon this the wall will rest. From this point water will be reached by a number of additional borings about the central tube, originally inserted, and tubes introduced to the gravel stratum. These tubes will project about 3 feet above the bottom and the pump suction will extend somewhat below their tops so that when it is necessary to clean the well the water may be drawn down, the tubes capped, and cleaning effected. The well bottom will be finished in cement.

The pumps are located about 25 feet distant and set 25 feet below the surface. On the level with the pump foundations the water and pump wells will be connected by a tunnel through which the suction and relief pipes will be laid after which it will be securely closed.

The more novel features presented in the above construction are to be credited to the suggestions of the local committee who, after their experience, will be able and doubtless willing to afford valuable hints to others investigating the same subject.

The works at Sycamore are mainly designed to secure fire protection to the business portion of the city. The standing contents of the well will be about 13000 gallons, and the flowing supply, as approximately shown by the tube first sunk, can be made far more than adequate to meet all possible demands. A splendid pair of Blake's Direct Acting Steam Pumps 16x8x24 taking steam from the capacious boiler of the Marsh Harvester Works are in place. The works were put in by T. B. Farrington, of Chicago, and are in every respects complete and effective.

Baltimore, Pittsburgh and Chicago Railway.

DISTANCE AND ELEVATIONS AT STATIONS AND PROMINENT POINTS.

STATIONS.	Distance in miles	Elev'n above L. Erie—feet	Elev'n above Atlantic Ocn
Chicago Junction	0.0	357	930
Attica	8.2	390	963
Republic	15.9	311	884
C. S. & C. Crossing	24.0	182	755
Tiffin	24.3	185	758
Bascom	30.0	209	782
Fostoria	36.8	213	786
L. E. & L. R. R.	37.4	212	785
Ridgefield	40.8	205	778
Bloomdale	44.2	182	755
Bairdstown	47.0	173	746
New Baltimore	50.7	136	739
Hoyts Corners	56.6	147	720
Deshler	62.4	147	720
Hamler	69.6	149	722
Holgate	74.6	148	721
Standley	79.5	157	730
Top of East Abu't. Auglaize Bridge	86.9	132	705
W. & L. E. Canal Water Level	87.7	127	700
Defiance Junction	88.0	138	711
White's Mill	92.3	143	716
Top of East Abu't. Maumee Bridge	94.7	135	708
Deleware Bend	95.2	140	713
Mark Center	101.2	157	730
Hicksville	107.9	188	761
Hicksville Summit	111.2	276	849
St. Joe Bridge	114.5	239	812
St. Joe Station	115.1	242	815
Auburn Station	124.3	296	869
Auburn Junction—top of rail	124.8	301	874
Garrett City	128.2	318	891
Avilla Junction	133.3	388	961
Avilla Summit	135.3	441	1014
Albion	143.4	353	926
Sparta Lake, W. L.	151.0	328	901
Cromwell	153.4	364	937
Turkey Lake. H. W.	160.0	294	867
Syracuse	161.0	296	869
Milford Junction	165.7	267	840
Locke	172.8	307	880
Bremen	181.9	247	820
Michigan Road Summit	189.9	286	859
Tee Garden	193.4	220	793
Walkerton Junction	199.0	145	718
Kankakee Bridge	205.0	126	699
Union Mills Junction	213.6	185	758
L. N. A. & C. R. R.	220.8	214	787
Coburg	223.1	213	786
Coburg Summit	223.6	222	795
Suman	226.6	173	746
M. C. R. R. crossing	236.8	67	640
L. S. & M. S. R. R. crossing	241.3	44	617
Calumet River & Lake Mich. water lev.	258.2	16	589
South Chicago Avenue	258.5	21	594
Kingston (B. & O. R. R. shops	259.4	22	595
Ill. Central R. R. Junction	263.7	25	598
Chicago, Ill. Cen. and B. & O. depots.	271.2		

NOTE.—The elevations were calculated from the water level of the Wabash and Erie Canal as a *datum* line. The B. P. & C. Railway crosses the Wabash and Erie Canal at Defiance, between the fourth and fifth locks. is 127 feet above mean surface of Lake Erie. (Report of B. of P. Works of Ohio, for 1842.) From the report from the U. S. Geological Survey of the Territories made by James T. Gardner, Geographer, we have:

Mean surface of Lake Erie at Buffalo and Cleveland, from 1844 to 1857 above mean surface of Atlantic Ocean, 573 feet.

Lake Michigan at Chicago, (since 1853,)—589 feet above Atlantic Ocean, or 16 feet above Lake Erie.

It will be seen from the table of elevations of the B. P. & C. R. R., (calculating the elevations from Wabash and Erie Canal at Defiance and joining up at the Calumet river and Lake Michigan) that the elevation of Lake Michigan is 16 feet above Lake Erie, or 589 feet above Atlantic Ocean, corresponding exactly with the elevations given by Professor Gardner.

The elevations given in the above table indicates subgrade, which is 18 inches below top of rail.

CHAS. ACKENHEIL,
Ass't. Engineer B. P. & C. R. R.

Comparative Merits of Cement and Vitrified Sewer Pipe.

From careful examinations of the cement pipe taken up in Middletown during the past two years, and also from actual experiments which I have made during the past year for determining the comparative merit of cement pipe and vitrified stone, or vitrified clay pipes, as to strength, power to resist the action of acids, etc., I am led to recommend the discontinuance of the use of the cement pipe for the conveyance of general sewage matter, and the adoption instead of vitrified stoneware pipe for the smaller sewers, and of good, hard brick for the larger sewers. Of the cement pipe sewers taken up, nearly every section was more or less fractured along the top and bottom, and in many cases along the sides also, so as to fall in pieces in being lifted or moved. Experiments made early in the past year upon fair specimens of each kind of pipe have shown that the vitrified pipe has nearly double the strength of cement pipe to resist unequal pressure.

Vitrified pipe, whether thoroughly glazed or not, if well baked, or burnt, is not affected at all by clear sulphuric acid, even though immersed in it for a long time; while cement pipe immersed in sulphuric acid, immediately disintegrates. Very much diluted acids act readily on cement pipes. A drain of cement pipe recently taken up at the factory of the Middleton Plate Company was found to be eaten nearly, and in some of the pipes wholly through on the bottom, although the drain had been laid but four or five years, and only dilute muriaitc acid had passed through it. There had also been quite a stream of water constantly running through the pipe. I have also noticed the destructive effects of water closet drainage, in several instances, in house connection pipes. —*E. P. Augur, City Engineer, Middletown, Conn.*

Pocket Telemeter of M. Caumet:—Double Refraction.

(Comptes Rendus de l'academie des Science, Paris.)

The pocket telemeter, which I have the honor to submit to the judgment of the Academy, is composed of two essential parts. 1st. A system of two mirrors, arranged on a small plate of metal so as to make with each other an angle of 45°. One of them is fixed, the other is mounted upon a moveable bar: the angle between the mirrors can thus vary from 41° to 49°. 2d. A micrometic screw, carefully made, of ½ millimetre pitch. The head of this screw is a circle of one centimetre radius, divided on the circumference into fifty parts. This screw

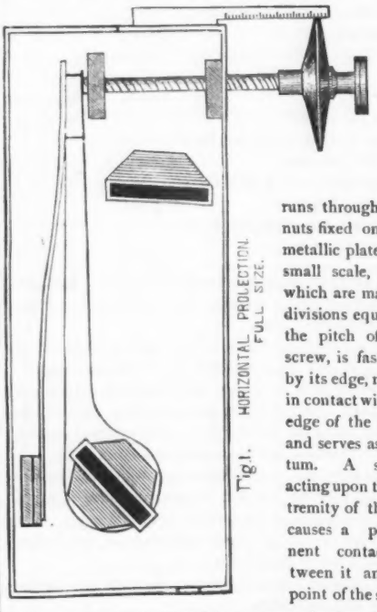


Fig. 1.

runs through two nuts fixed on the metallic plate. A small scale, upon which are marked divisions equal to the pitch of the screw, is fastened by its edge, nearly in contact with the edge of the head, and serves as a datum. A spring acting upon the extremity of the bar causes a permanent contact between it and the point of the screw.

These parts are arranged in a rectangular box, having at the posterior part a horizontal slit to look through and at the right a rectangular opening to admit the rays from the objects viewed by double refraction. Fig. 1 gives a horizontal projection, full size.

An observer wishing to measure the distance between two points, A and C, Fig. 2, places himself at A, so that

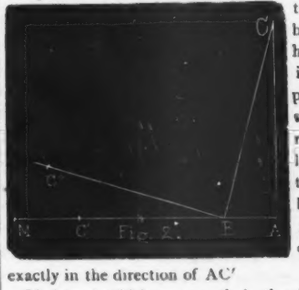


Fig. 2.

the point C shall be on his right; he then sees the image of C, at point C', by reason of the double reflection. He selects from among the objects before him in the field of view, a well defined point M, exactly in the direction of AC'

If the point M is not exactly in the direction AC', or, in other words, if the two points M and C are not in perfect coincidence, the observer makes them coincide by moving the image C by means of the micrometer screw.

This done, the observer moves to a point B in the direction AM, on which he has taken a base of some 20 to 40 metres. He will then no longer find the point C' in coincidence with M; that image will have to be moved to the right, to a point C'', C''B being perpendicular to BC. The observer renews the coincidence by turning the mirror by means of the screw. The angle of rotation of the mirror is measured by the number of divisions of the head of the screw which have moved past the scale. The quotient, of a constant number, for each instrument, divided by this number of divisions, gives the distance AC. This calculation can be avoided by the construction of a table giving immediately the distance corresponding to each number of divisions.

A great number of experiments have been made with this pocket telemeter, under the most different conditions; it is found from these trials that the probable error in determining a distance is about one fiftieth of that distance, when a base is taken at least equal to one one-hundredth. The employment of an eye piece, magnifying three, four or more times, will reduce the error about one-half, by diminishing the error of sighting. To measure several kilometres will not take more than three minutes.

The double reflection telemeter, whose small dimensions make it a real pocket instrument, is simple, very portable, quite convenient, sufficiently accurate, and advantageous in reconnaisances or preliminary surveys. I have also used the measure of the angle of rotation of one mirror to construct an instrument with single reflection, to which I have given the name of telemetric telescope, because of its double use as spy-glass and as telemeter.

EXTENSIVE ART-GALLERY.—Next to the Bible, no book is more useful than Webster's Dictionary. The Unabridged is an *extensive art-gallery*, containing over three thousand engravings, representing almost every animal, insect, reptile, implement, plant, etc., which we know anything about. It is a vast library, giving information on almost every mentionable subject. It indeed has been well remarked that it is the most remarkable *compendium of human knowledge* in our language.—*Honsehold Advocate.*

Manufacturers' Intelligence

Messrs Cregier, Clark & Co., of this city, have recently added three new heading machines and a 60 horse power engine and boiler to the manufacturing capacity of their establishment. They have contracts ahead for over 500,000 lbs. of bolts of different descriptions.

The Scoville Iron works, of this city, are now engaged in building two pair of engines, each double propeller, 10 x 12, for two new steam canal boats, one belonging to the Excelsior Stone Co, the other to Boyer & Corneau, to be placed on the Illinois & Michigan canal the coming season.

The Vulcan Iron works, of this city, are at work upon the machinery for a new steam dredge for the U. S. Government, to be used on the Fox River Improvement under Col. Houston, Major of Engineers U. S. A. in charge. This will be one of the largest and finest dredges ever constructed in America, being a self-propeller, driven by two propeller wheels by an engine for that especial purpose. The hull is being built at Winneconne, Wis. and will be launched about the middle of April. The total cost of construction will be about $28,000.

The establishment is in a highly prosperous condition and has contracts ahead for over two months.

Contractors' Intelligence.

Ground was broken for the new Court House at Quincy, Ill., last Monday.

The Union Steamboat Co. have leased the south 300 feet of the block on the water line of the South Branch of the Chicago River, between Randolph and Washington streets, and have just commenced the construction of the necessary docks, warehouses, etc., for the accommodation of their business. Conro, Carkin, and Co. have the contract for the building of the docks, Daegling and Messersmith for the masonry, and C. H. Blair for the carpenter work. C. P. Thomas is the architect.

Messrs Earnshaw and Gobel, Mason Contractors, of this city, are building the entire structure, above ground, of the Chicago (west side) Pumping Works. The dimensions of the engine room are to be 100 x 66 feet, and 50 feet high, the boiler room, 100 x 40 feet, and 30 feet high, the office 20 x 40 feet, and two stories high, and the stack 130 feet in height. The entire building is to be constructed of Indiana pressed brick with stone trimmings and iron roofs and will be built throughout in the most approved manner. The work, by the terms of the contract, is to be finished May 15, the cost being about $66,000.

The Water Works at Lafayette, Ind. have been completed and accepted.

Proposals have been made by two parties for the construction of the Marquette and Mackinaw (Mich.) railroad, for which the State has granted 1,300,000 acres of land.

Mr. Isaac S. Cassin, Engineer, of Philadelphia has been awarded the contract for the new water reservoir at Wilmington, Del. It will have a capacity of nearly 40,000,000 gallons.

Fort Wayne, Ind. has voted, 13 to 5 in the Council, for Water Works. We do not know what system will be adopted: the competition is between the Holly Manufacturing Co, and H. R. Worthington, New York.

Proposals for Contracts.

OLD COURT HOUSE FOR SALE.—Proposals for the purchase of the Old Court House at Springfield. Ill., will be received at the office of the county clerk of Sangamon county, until noon of Thursday, April 18, 1876. George Pickerell, W. M. Warren, J. S. Highmore, *Special Committee.*

POLICE STATION,—Proposals will be received until Monday, April 3, 1876, at 12 m., for building an addition to the Sixth Precinct Station House, Brooklyn, N. Y. according to plans and specifications on file in the Department of city works By order of the Common Council. Henry W. Slocum, Wm. A Fowler, Thos. W. Adams, *Commissioners of City Works.*

Commissioners' Office, Hamilton Co., Ohio }
March 8, 1876. }

EMBANKMENT AND APPROACHES.—Sealed proposals will be received at this office until Friday, April 7, 1876, at 12 o'clock m., for making embankment and approaches to the Union Bridge over Little Miami River, between Spencer and Anderson townships. Specifications and profile can be seen at this office. By order of Commissioners. Joseph B. Humphreys, *Auditor.*
By Jas. F. White, Deputy.

SCHOOL HOUSE.—Bids for remodeling the Jefferson School House, (late Quincy College) will be received by the Board of Education until April 1, 1876, at 2 o'clock p. m. Specifications, detail drawings, and form of the bid to be proposed, may be seen at the office of Robert Bunce Esq., Quincy, Ill. By order of the Board of Education. Gustav Levi, Herman Schrœder, T. W. Macfall, *Committee on Buildings and Grounds.*

STONE OR IRON BRIDGE.—Sealed proposals will be received at the office of the County Commissioners, in the city of Wilkes-Barre, until Tuesday, April 4, 1876. at 2 o'clock p. m., for building a Stone or Iron Bridge over Abraham's Creek, in Kingston township, on the road leading from the village of Wyoming to Orange, near the point where the L. and B. railroad crosses said road. N. N. Dean, Samuel Line, Peter Jennings, *County Commissioners.*
Wilkes-Barre, March 3, 1876.

Engineer's Office, District of Columbia, }
Washington, D. C., March 17, 1876. }

SWEEPING ANE CLEANING STREETS.—Sealed proposals will be received at this office until 12 o'clock m., on Wednesday, April 5, 1876, for sprinkling, sweeping and cleaning the streets and avenues in the cities of Washington and Georgetown, for the period of one year from the sixth of May, 1876. Blank forms and all necessary information can be obtained upon application at this office, and no bid will receive consideration unless made upon said blank forms. By order of the Commissioners. R. L. Hoxie, *Lieutenant Engineers U. S. A., Engineer D. C.*

IRON TRUSS BRIDGE.—Sealed proposals will be received by the Commissioners of Cass County, Indiana, at their office in Logansport, Indiana, until 12 o'clock, noon, on the 20th day of April, 1876, for the erection of a Wrought Iron Truss Bridge, over Eel river, at the North end of Sixth street, in the city of Logansport. Said bridge to have two spans, one span 110 feet and one span 112 feet extreme lengths, with one roadway 20 feet clear width, and two footways 6 feet clear width each; to have 3-inch oak floor on roadways and 2-inch pine floors on footways, with all oak joists. The bridge to have iron floor beams and wrought iron footway fences, with posts secured on floor beams. Capacity of bridge to be 100 lbs. per square foot of roadway, and 60 lbs. per square foot of footways, exclusive of bridge weight. No iron to be strained over 13,000 lbs. per square inch in tension, 8,000 lbs. per square inch in shearing, and 9,000 lbs. per square inch in Gordon's formula for compression strains. Builders must furnish full plans and detailed specifications, giving forms and dimensions of girders, size of each part of bridge, together with strain sheets, giving weight of bridge with maximum strains under the specified load, and the cross-section of each principal part in square inches. Bids to be made per lineal foot for extreme length of superstructure. Proposals not in accordance with this advertisement will not be considered, and the right is reserved to reject any and all bids. John Hynes, Dennis Uhl, Daniel Foglesong, *Board of Commissioners, Cass County.*

SCHOOL HOUSE.—Proposals will be received by the Carthage Village Board of Education, until noon, March 30, 1876, for the erection of a school house, in Carthage, Hamilton Co., Ohio, according to the plans and specifications on file at the office of George Humphreys, Architect, 74 West Third street, Cincinnati, Ohio. Bids to be filed with the Clerk. John H. Dorwan, *Clerk.*
Cincinnati, March 2, 1876.

U. S. Engineer's Office, 85 Washington Ave., }
Detroit, Mich., March 17 1876, }

STONE.—Sealed proposals, in duplicate, will be received at this office until 3 p. m. of Friday, the 31st day of March, 1876, for the Stone for St. Mary's Falls Canal Improvement. For information upon the subject apply in person at this office. G. Weitzel, *Major of Engineers.*

Commissioners Office, Hamilton Co., Ohio, }
Cincinnati, Feb. 29, 1876. }

LEVEE.—Sealed proposals will be received at this office until Saturday, April 1, 1876, at 12 o'clock m., for making a Levee of about four hundred and fifty feet at the south end of the bridge across the Great Miami River at New Baltimore, in Colrain township. Specifications can be seen at this office. By order of Commissioners. Joseph B. Humphreys, *Auditor.*
By Jos. F. White Deputy.

BRICK COAL HOUSE.—Proposals for a brick coal house to be erected on the La Salle county farm will be received at the office of H. C. Furness, Architect, until Monday 3rd day of April, 1876. Plans and specifications of same can be seen at said office where all necessary information will be furnished. G. W. Jackson, *Supt. of Poor, Ottawa, Ill.*

COAL.—Proposals are invited for the coal supply of the Union Steamboat Co., for the season of 1876. Coal to be delivered free on board at convenient dock. Address or apply before April 1st, to W. Bullard, *General Manager.*
No. 5 Ohio St., Buffalo.

Office of Township Clerk of Bedford.

SCHOOL HOUSE.—Sealed proposals will be received by the undersigned at the office of the Township Clerk, until 12 o'clock noon of April 17th, 1876, for the construction of a brick school house in sub-district No. 1. James A. Black, George Long, Osro Osborn, *Committee on Buildings.*
Bedford, N. Y. March 13, 1876.

JAIL.—Plans and specifications for a jail to be built at Troy, Missouri, are called for, the same to be submitted to the Court in Troy on the 10th of April, 1876. The general plan of said jail to be two stories in height of brick, with four medium sized cells in the second story, and two offices in the lower story, one room for insane, and also two rooms for jailer's residence, and the total cost thereof not to exceed $10,000; the Court to select the plan and submit the building of said jail in accordance with said plan to competition.
Wm. A. Woodson. *Clerk of the County Court.*

COUNTY POORHOUSE—Sealed proposals will be received until Tuesday the fourth day of April, at 12 o'clock noon, for the building of an additional Ward to the County Poorhouse building, according to plans and specifications to be seen at the office of the County Auditor, Marion, Iowa. By order of the Supervisors. Joseph Whitney, *Chairman.*

SCHOOL HOUSE.—Sealed proposals will be received at the office of the Clerk of the Board of Education of Northampton Township, Summit County, Ohio, until 12 o'clock at noon, on the seventeenth day of April 1876, for building a School House on the lot situated in Sub-district No. 1, according to the plans and specifications on file in said office.
By order of the Board of Education,
H. A. PACKARD, *Clerk.*

O. B. GREENE, *Pres.* THOS. BURGESS, *Supt.*
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FitzSimons & Connell,
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Wm. B. Howard,
Room 16, Metropolitan Block, Chicago.

J. E. Miller & Co.
34 South Clark Street, Chicago, Ill.

Ray & Whitney,
West end 12th Street Bridge, Chicago, Ill.

Steel & McMahon,
86 LaSalle Street, Chicago, Ill.

Cas and Water Works.

T. B. Farrington,
101 Washington Street, Chicago, Ill.

Railways.

John H. Cutches,
84 La Salle Street, Chicago, Ill.

Bridges.

The American Bridge Co.,
See Advertisement.

Wells, French & Co.,
144 Dearborn Street, Chicago, Ill.

Mason Work.

Barker & Smull,
148 Madison street, Chicago.

T. H Bryant,
Hyde Park, Ill.

Busse & Sturtevant,
126 Dearborn Street, Chicago.

D. H. Call,
47 North Ashland avenue, Chicago.

T. E. Courtney,
87 Washington Street, Chicago.

Cox Brothers,
1639 Prairie Avenue, Chicago.

Dameier & Elder,
Room 11, 106 5th avenue, Chicago.

Earnshaw & Cobel,
164 East Randolph street, Chicago.

Niegelsen and Shields
Room 51, Major Block, Chicago.

Pavements.

D. D. McBean,
Room 4, 79 Dearborn Street, Chicago, Ill.

James G. McBean,
77 Clark Street, Chicago.

J. B Smith,
151 Randolph Street, Chicago. Ill.

Asphalt Paving.

J. L. Fulton & Co.,
174 LaSalle Street, Chicago.

Sewer Pipe Manuf's.

Cladding, McBean & Co.,
Lincoln, Placer Co., Cal.

Roofs, Cornices, &c.

J. W. Atkinson,
313 to 321 Clinton street, Chicago.

A. Knisely & Co.,
72 and 74 W. Monroe street, Chicago.